Decadal Changes in Northeast Adaptability, and Vulnerability to Climate, Insects and Disease

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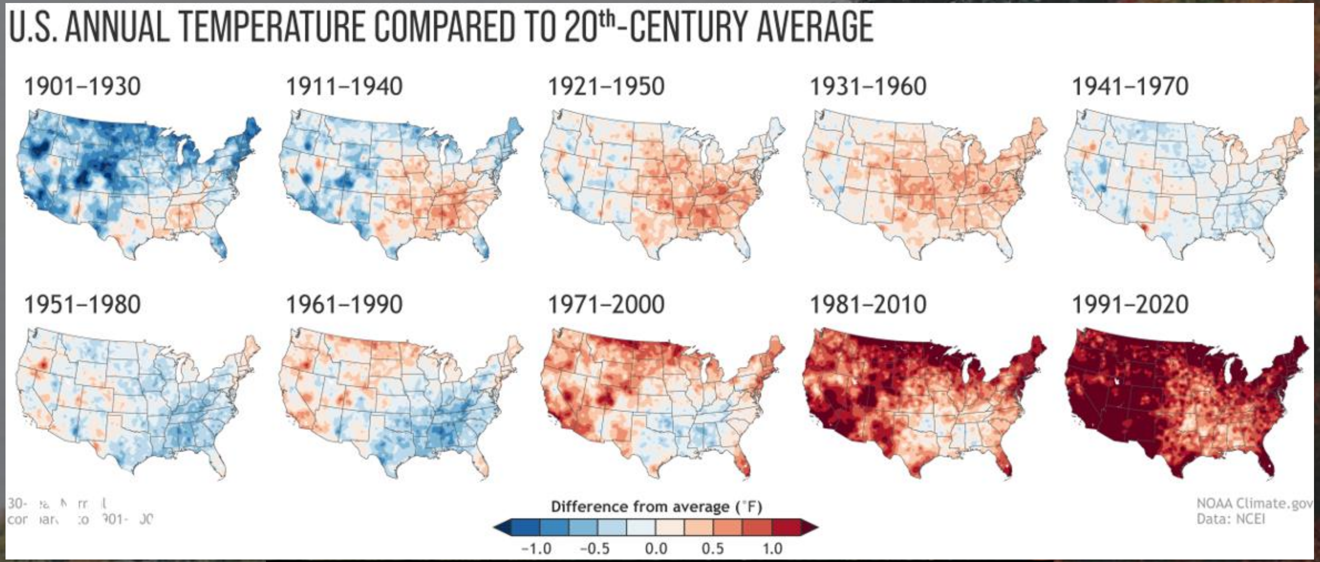
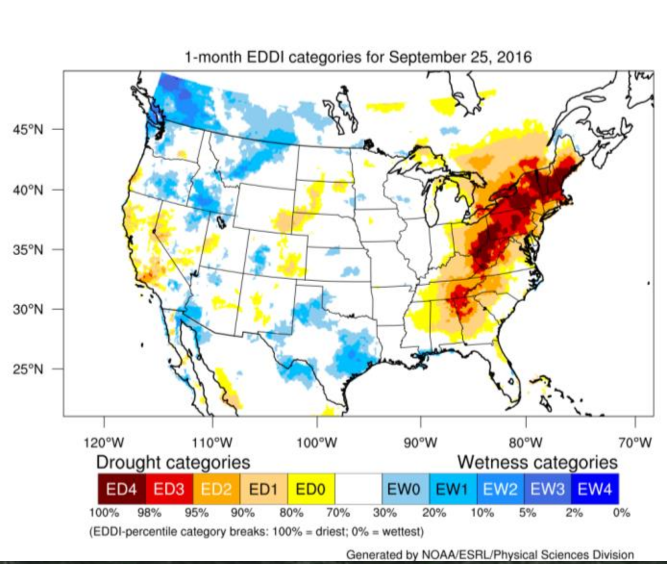
FEMC

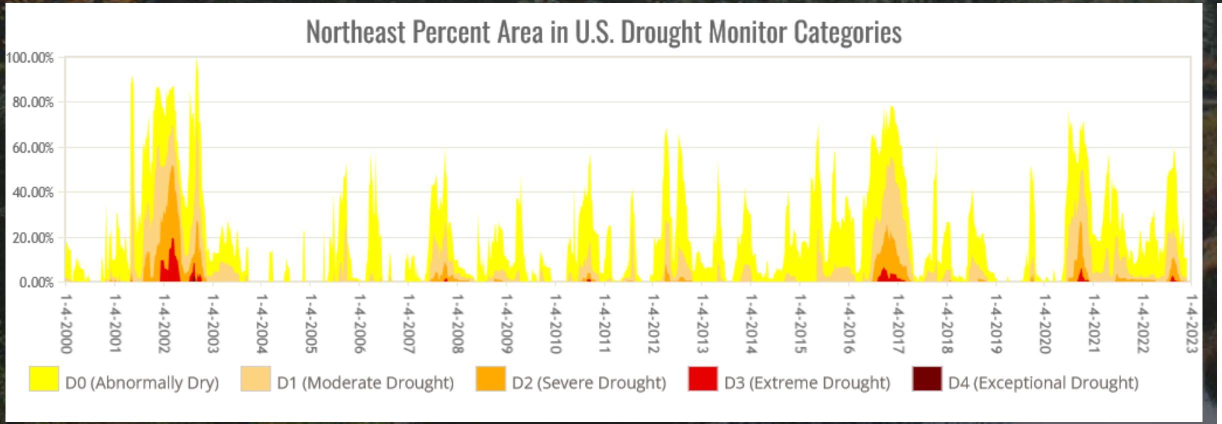
Changes in Climate Regime

Increasing temperatures

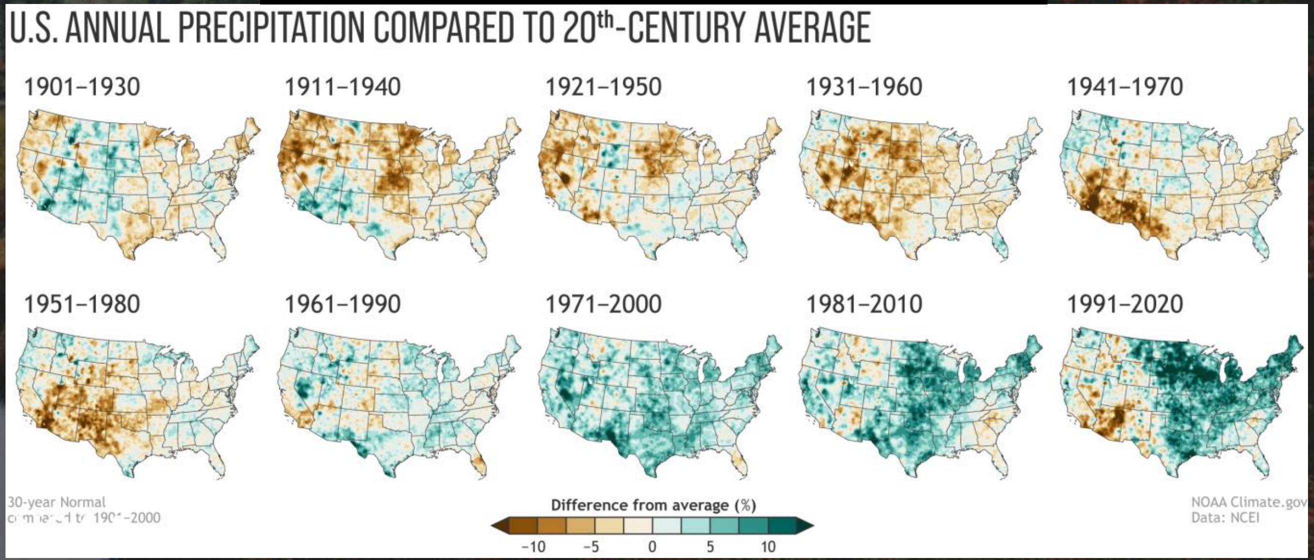




Increasing drought frequency

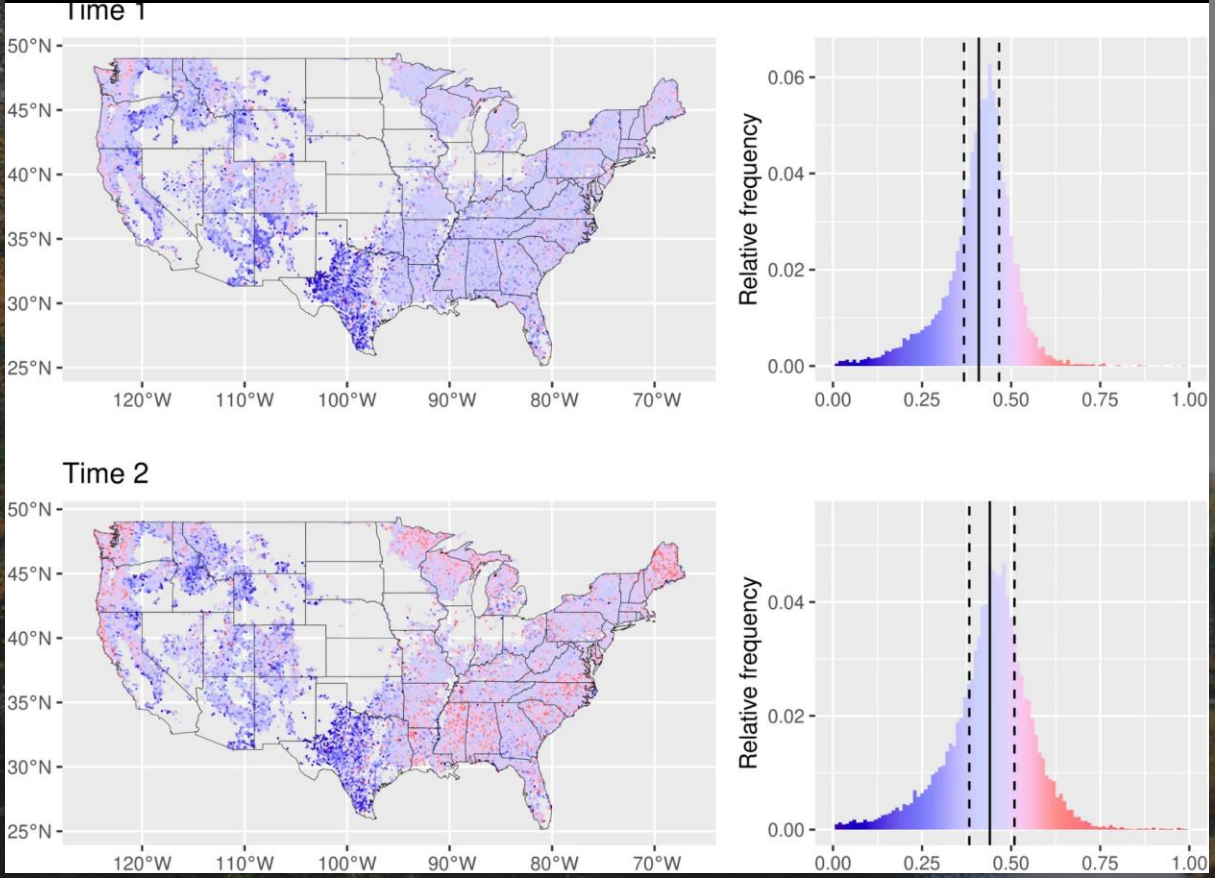


Increasing Rainfall



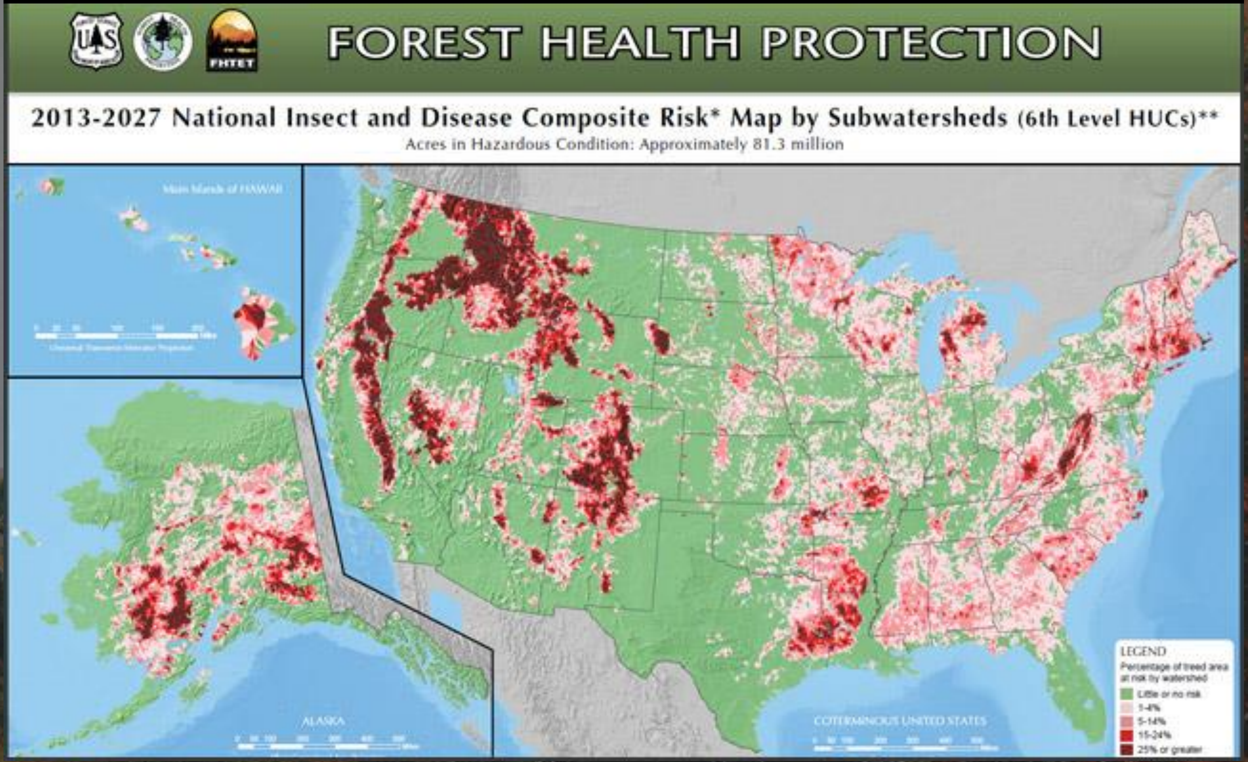
Changes in Stand Dynamics and Insects and Disease

Increasing Relative Densities



Woodall & Weiskittel . 2021

Increased Risk to Insects and Disease



Krist et al. 2018

Driving Questions

Have changes in forest structure and composition resulted in increased vulnerability to climate, insects and disease?

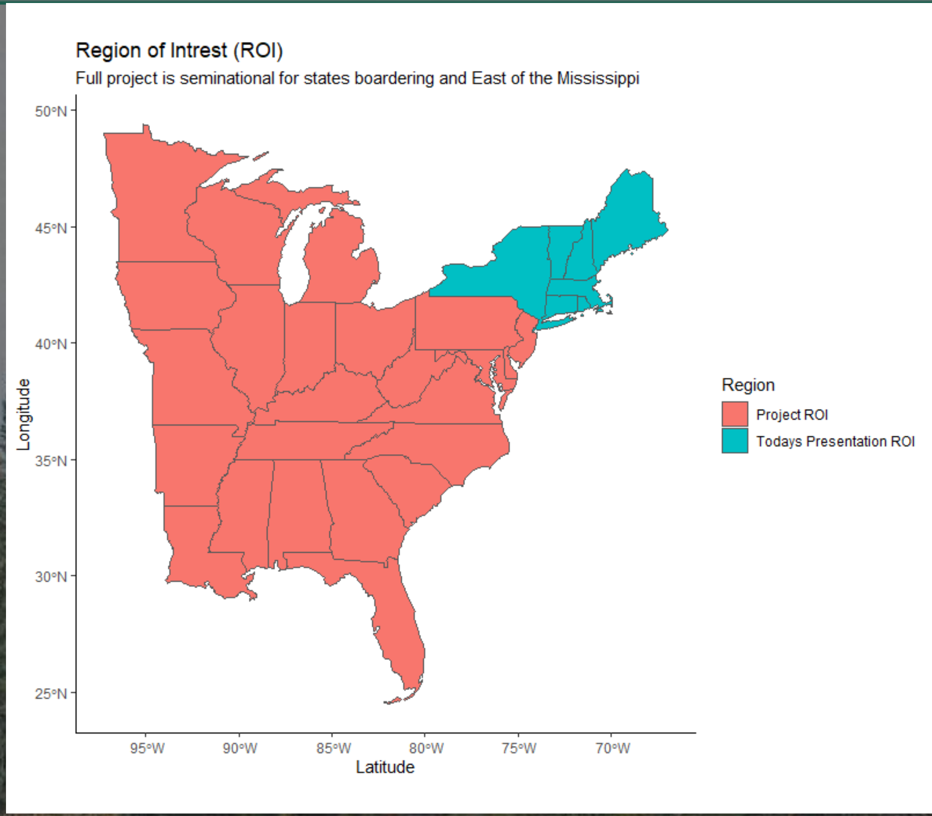
Are these changes consistent in both overstory and understory?

Are there any specific regions in which these changes are occurring or not occurring?

Region of Interest

Spruce Fir

Soren Donisvitch (L) and Shane Miller (R) Photo: J. Zukswert.



Oak-Pine

Hemlock-Hardwoods

Maple-Beech-Birch

Pitch Pine - Oak

Photo: Patricia Swain

3 Scoring Systems

Vulnerability to Climate

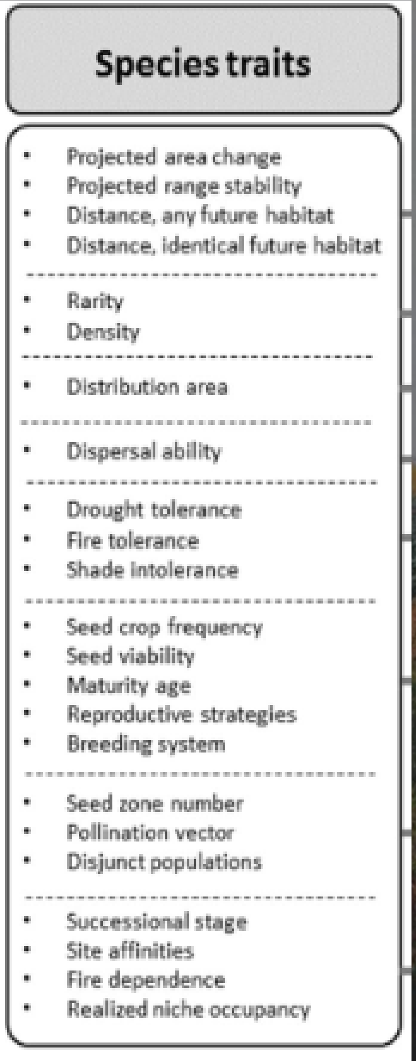
Potter et al., 2017

Vulnerability to Insects and Disease

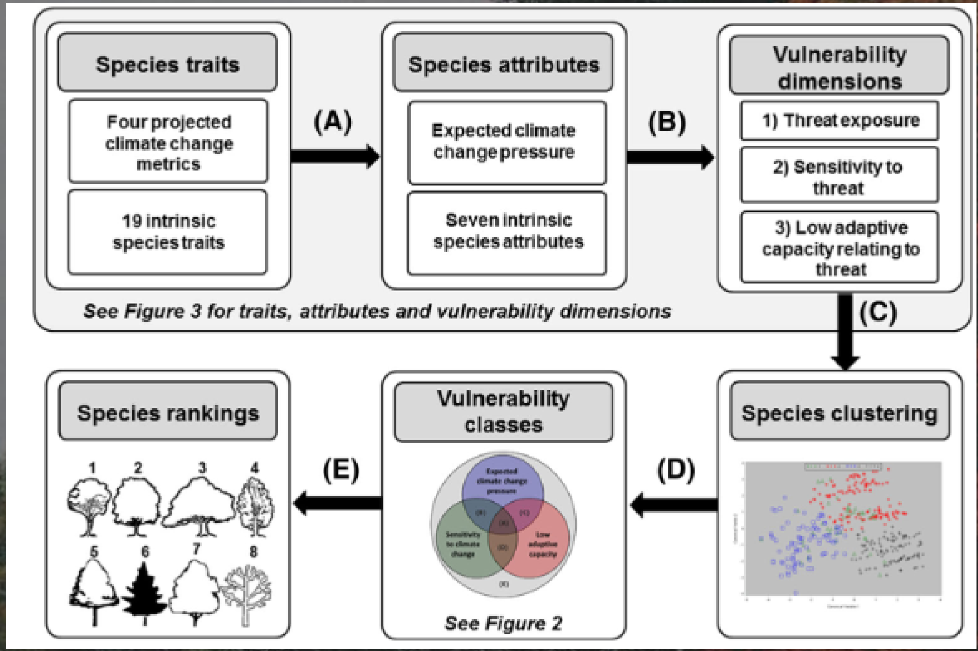
Potter et al., 2019

Adaptability MODFACs

Mathews et al., 2012

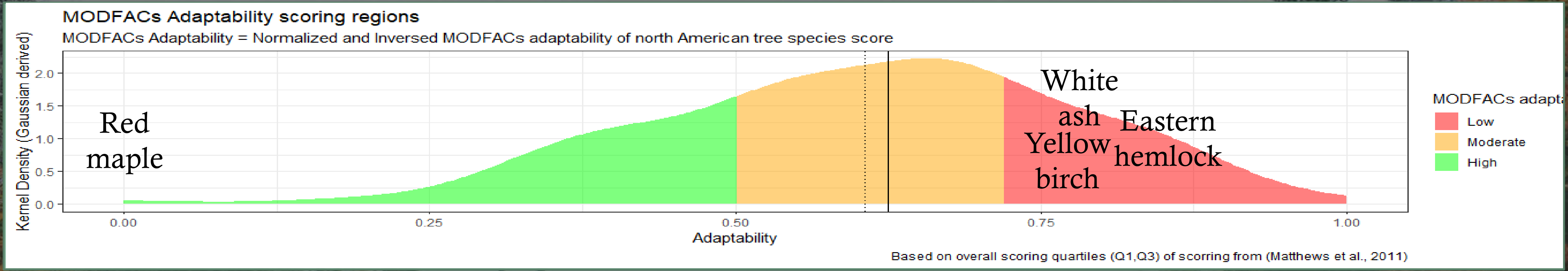


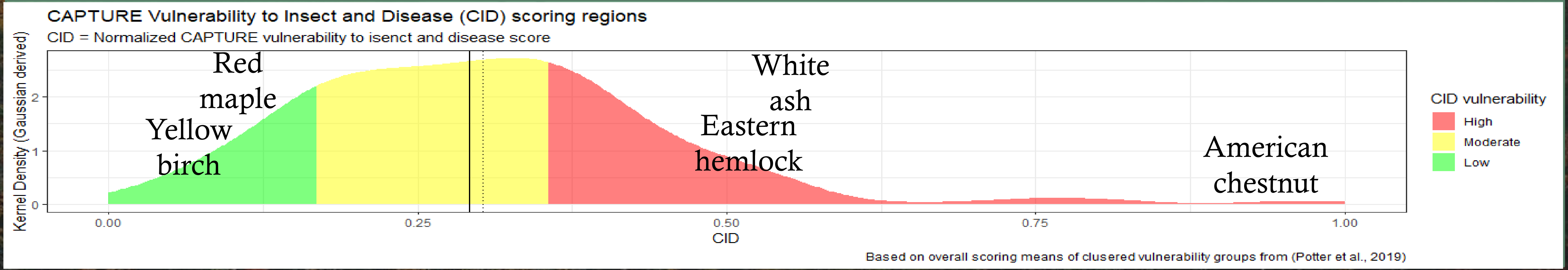
Potter et al., 2017

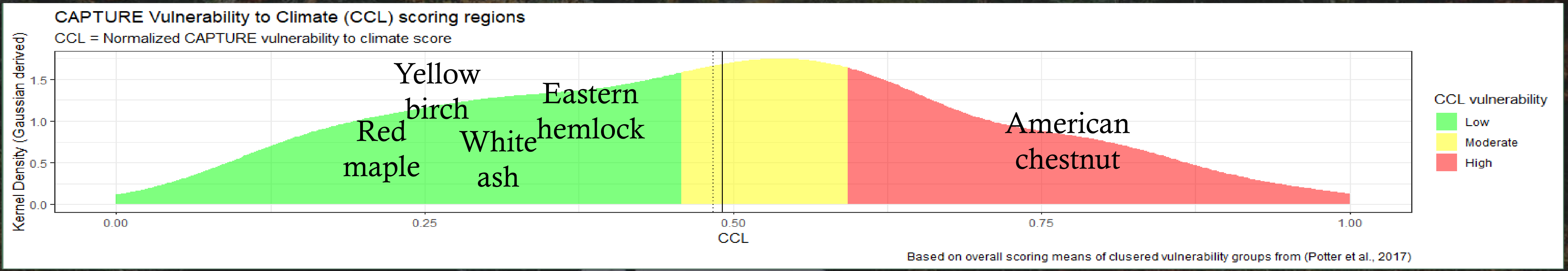


Individual species scores

The Scores

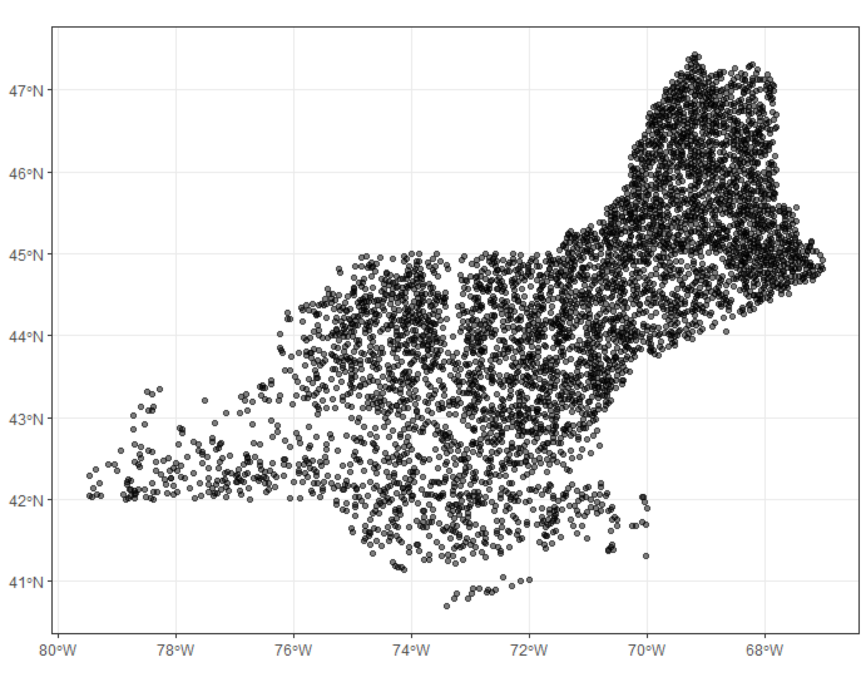

MODFACs Adaptability scoring regions
MODFACs Adaptability = Normalized and Inversed MODFACs adaptability of north American tree species score
Kernel Density (Gaussian derived)
2.0
1.5
1.0
0.5
0.0
Red maple
White ash
Yellow birch
Eastern hemlock
0.00
0.25
0.50
0.75
1.00
Adaptability
MODFACs adapt
Low
Moderate
High
Based on overall scoring quartiles (Q1,Q3) of scorring from (Matthews et al., 2011)


CAPTURE Vulnerability to Insect and Disease (CID) scoring regions
CID = Normalized CAPTURE vulnerability to isenct and disease score
Kernel Density (Gaussian derived)
2
1
0
Red maple
Yellow birch
White ash
Eastern hemlock
American chestnut
0.00
0.25
0.50
0.75
1.00
CID
CID vulnerability
High
Moderate
Low
Based on overall scoring means of clusered vulnerability groups from (Potter et al., 2019)


CAPTURE Vulnerability to Climate (CCL) scoring regions
CCL = Normalized CAPTURE vulnerability to climate score
Kernel Density (Gaussian derived)
1.5
1.0
0.5
0.0
Yellow birch
Eastern hemlock
Red maple
White ash
American chestnut
0.00
0.25
0.50
0.75
1.00
CCL
CCL vulnerability
Low
Moderate
High
Based on overall scoring means of clusered vulnerability groups from (Potter et al., 2017)

USDA Forest Inventory And Analysis (FIA)

Select and Filter Plot-plot max time



Apply Scoring Frameworks to individual species for tree and seedling plots

2 sample* comparison approach

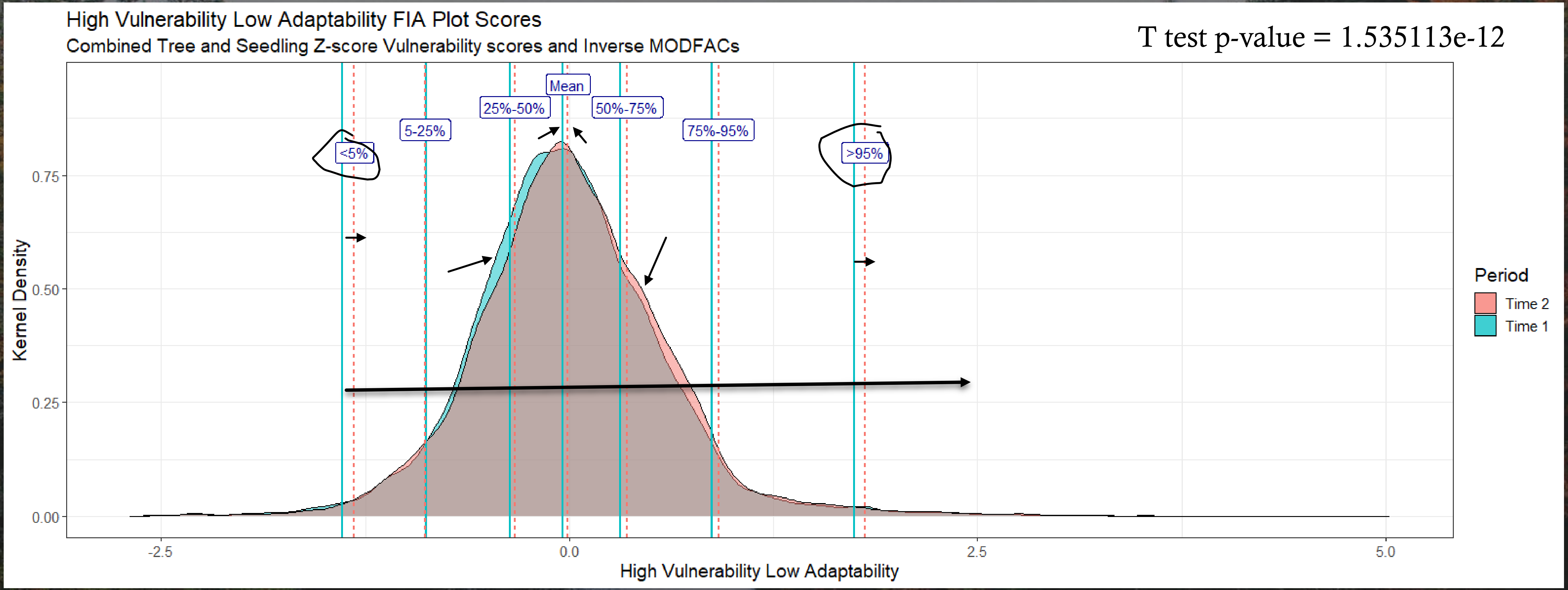
Number of plots = 25713
Median Time Difference = 15 years
Average ROI plot score error ~ 0.014

Time 1	Time 2
• 1998-2012 • N=25713 • Plot – Plot • Filter score error	• 2013-2021 • N=25713 • Plot – Plot • Filter score error

* Following methodology employed in Woodall & Weiskittel . 2021

Northeast HVLA Change Distribution

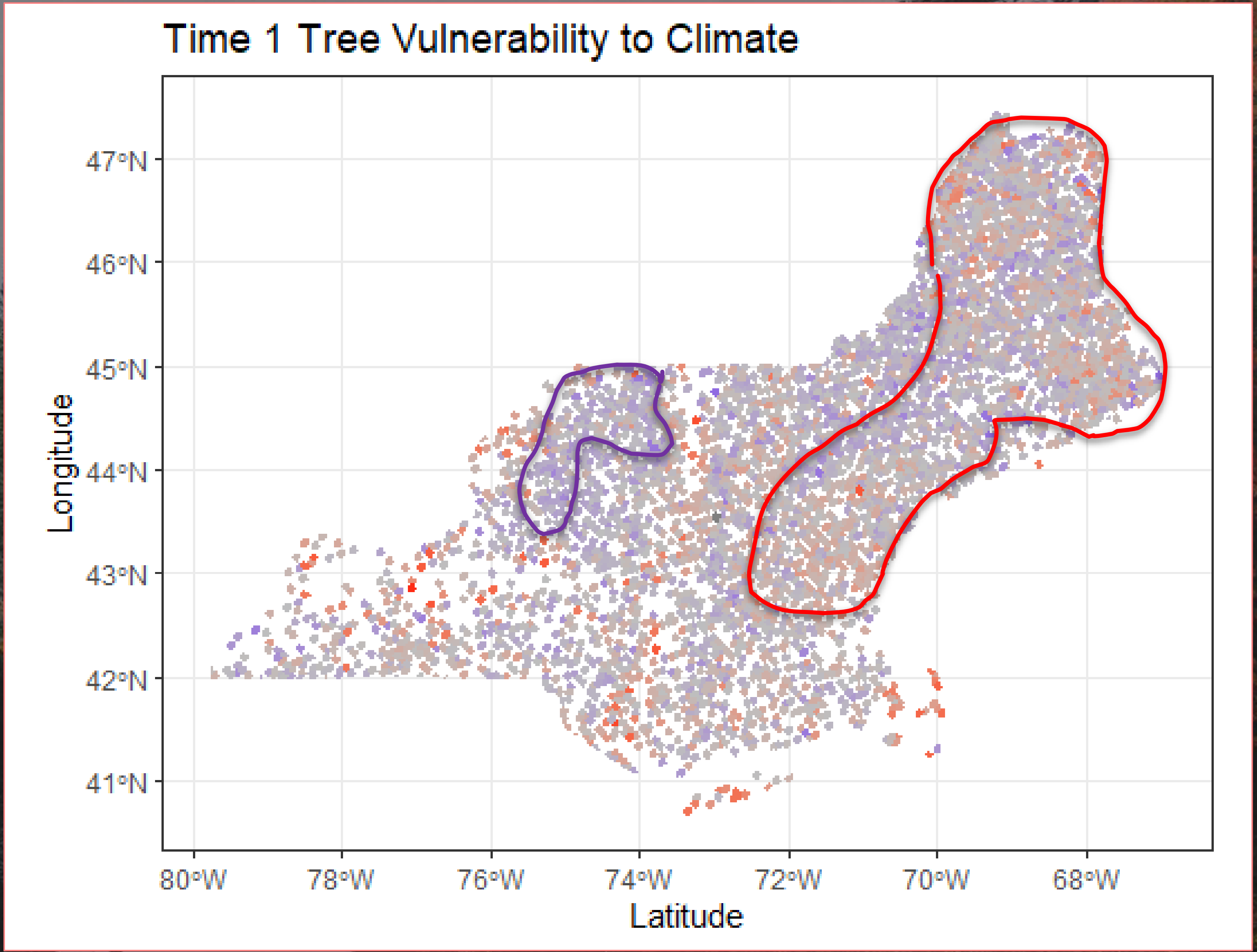
$$HVLA = Adaptability_{tree\ plot*} + CCL_{tree\ plot} + CID_{tree\ plot} + Adaptability_{seedling\ plot} + CCL_{seedling\ plot} + CID_{seedling\ plot}$$



* Note tree plots had scores calculated using biomass weighting $\bar{x}_w = \frac{\sum_{i=1}^{n}(x_i \cdot \omega_i)}{\sum_{i=1}^{n} w_i}$

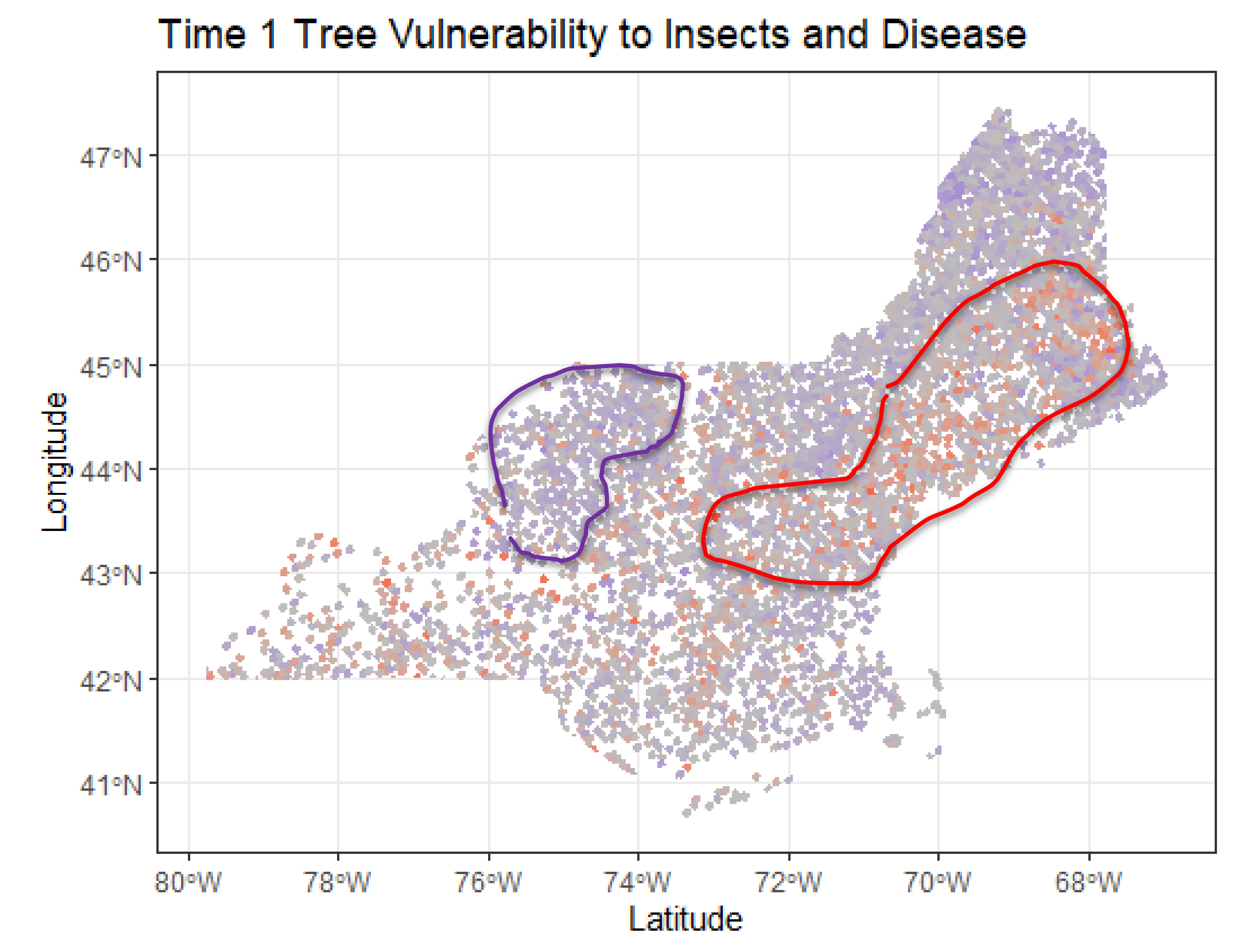
Northeast Vulnerability to Climate

- Spatial patterns show regions with higher vulnerability to climate
  - Northeastern Maine and central Acadian transition
- Regions with less vulnerability to climate
  - North Adirondacks



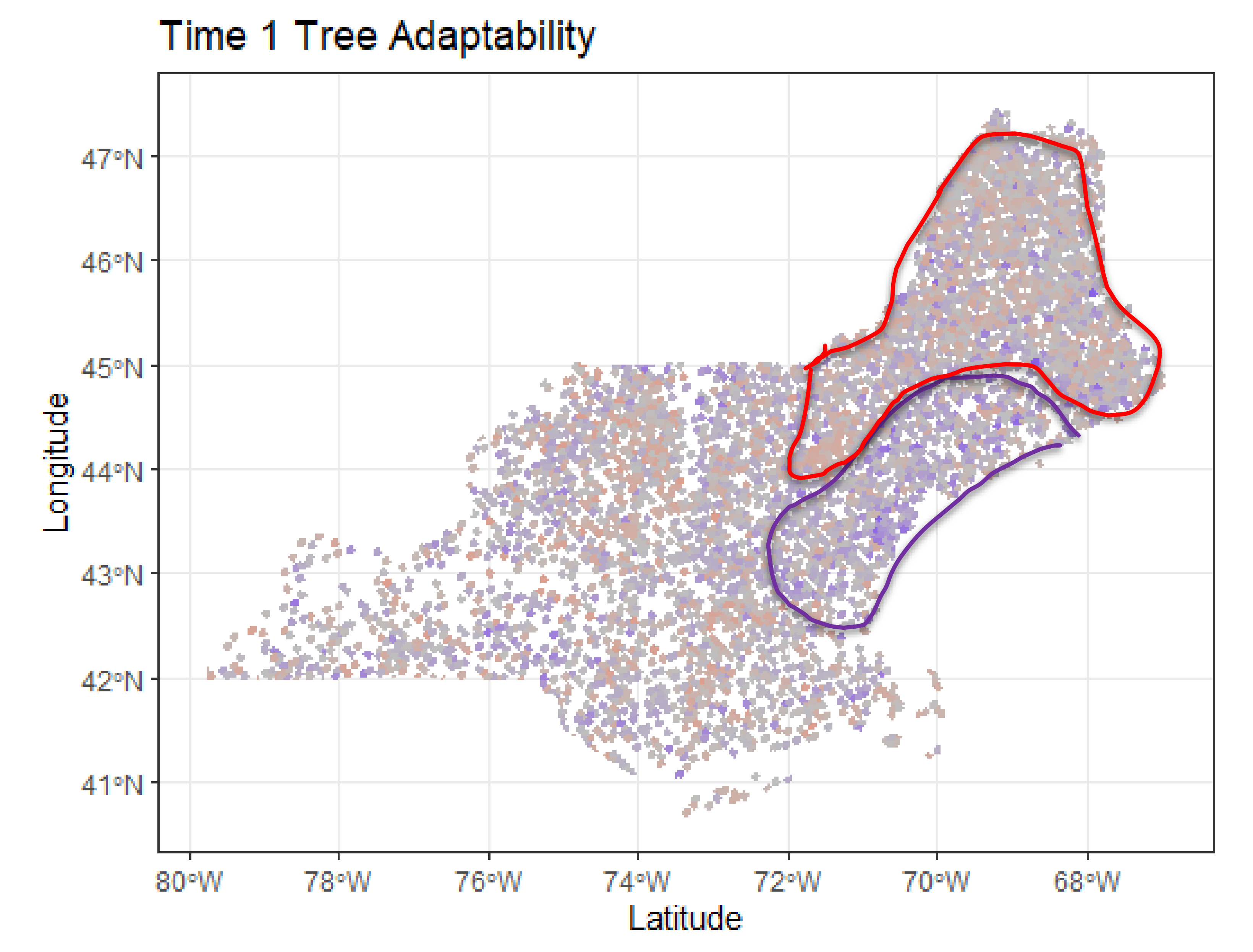
ROI Vulnerability to Insects and Disease

- Spatial patterns show regions with greater vulnerability to Insects and Disease
  - Eastern Maine and central Acadian transition
- Regions with less vulnerability to Insects and Disease
  - Northern Adirondacks



ROI Adaptability

- Spatial patterns show regions with less Adaptability
  - Northeastern Maine and central Acadian transition
- Regions with greater Adaptability
  - Central coastal Maine

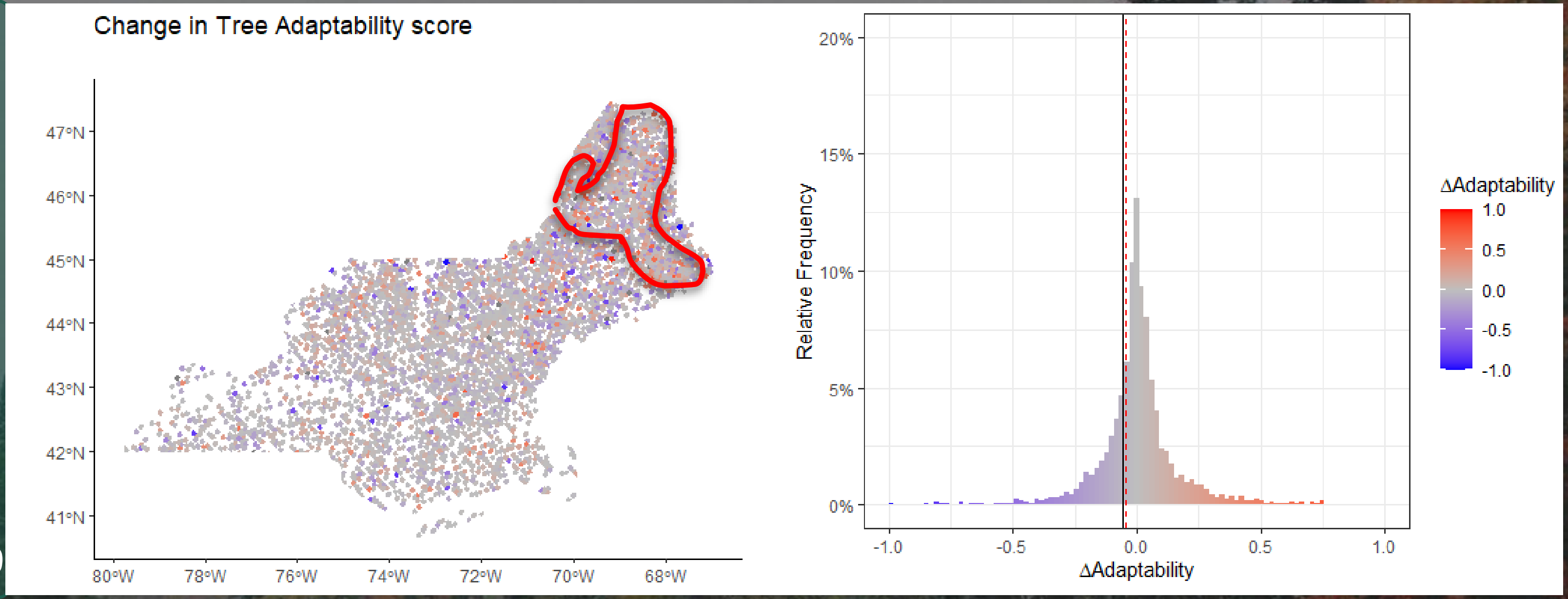


Changes in Adaptability

- Spatial patterns show regions with decreased Adaptability
  - Northern spruce hardwoods
- Regions with increased Adaptability
  - Sporadic changes in Hudson river valley (seedlings)
- Largest changes in understory

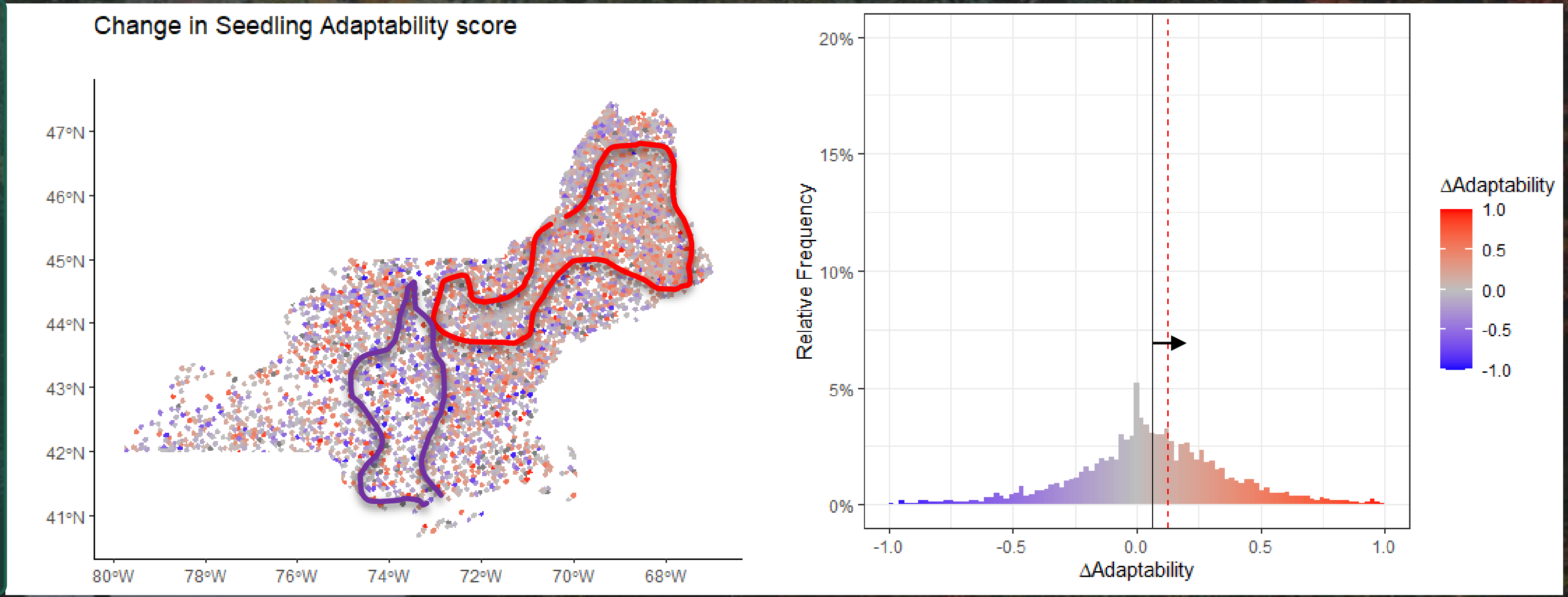
Tree

p = 0.30



Seedling

p = 0.00

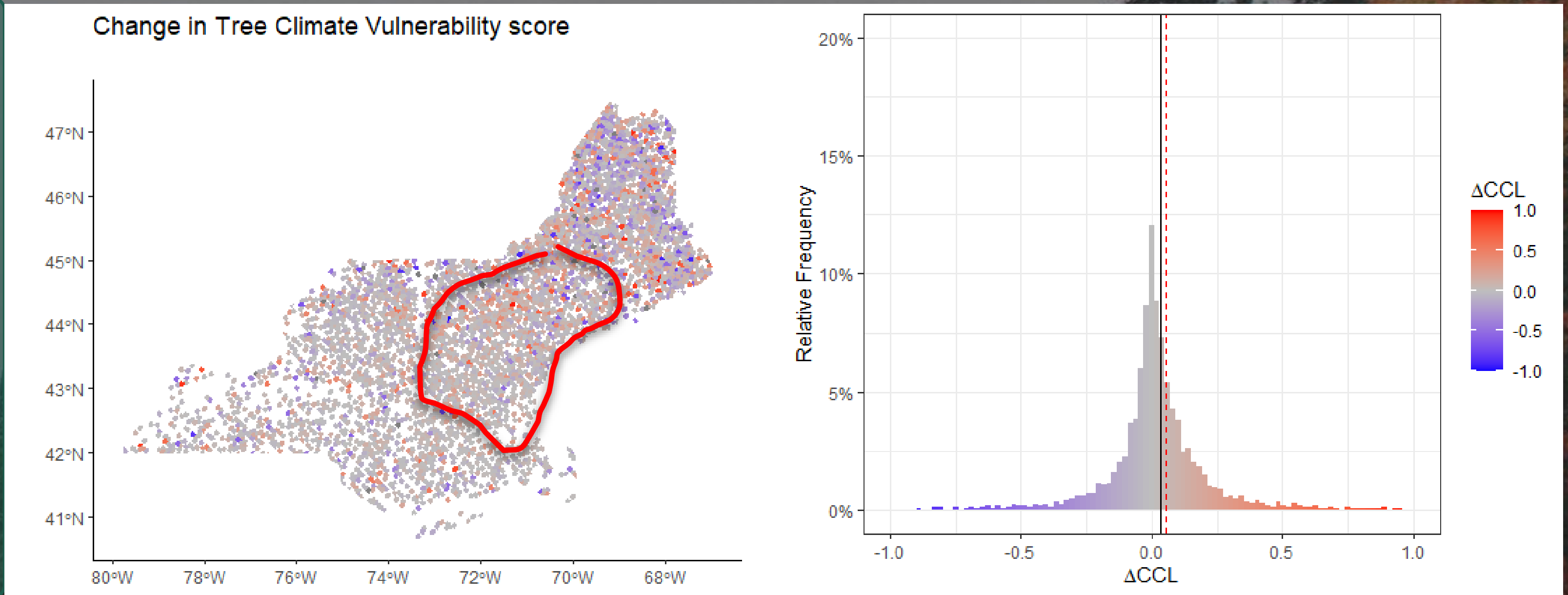


Changes in Vulnerability to Climate

- Increase in Vulnerability to Climate
  - Central Acadian transition
- Reduction in Vulnerability to Climate
  - North Adirondacks (seedlings)
- Largest average change in overstory
  - Likely due to sporadic increased in understory diversity

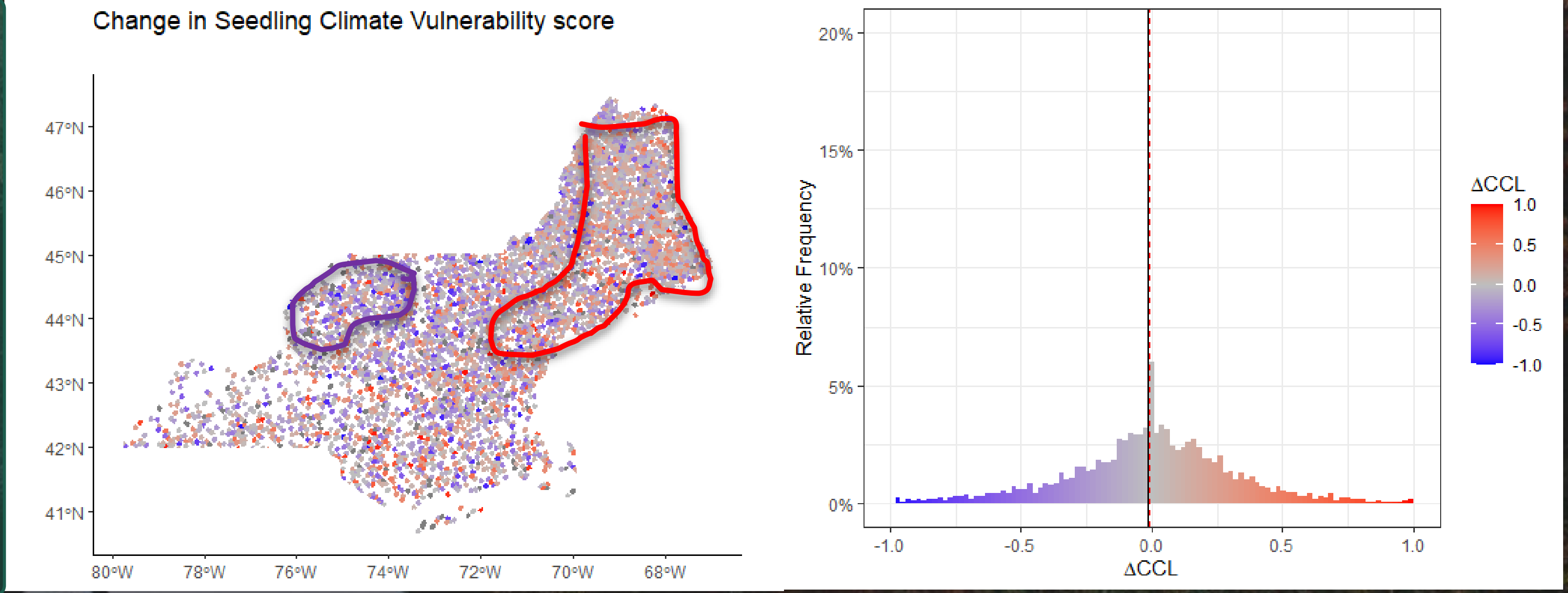
Tree

p = 0.02



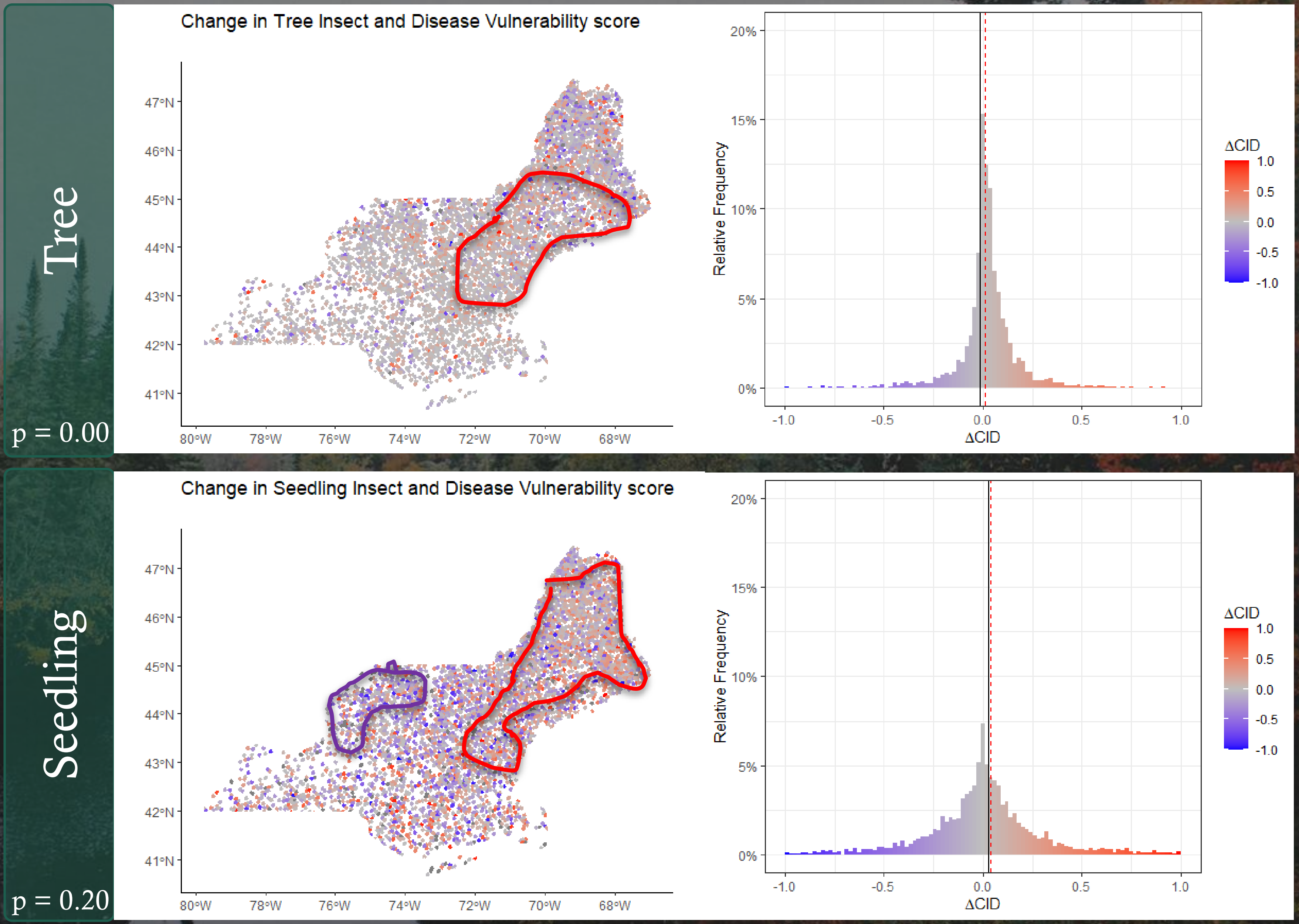
Seedling

p = 0.31



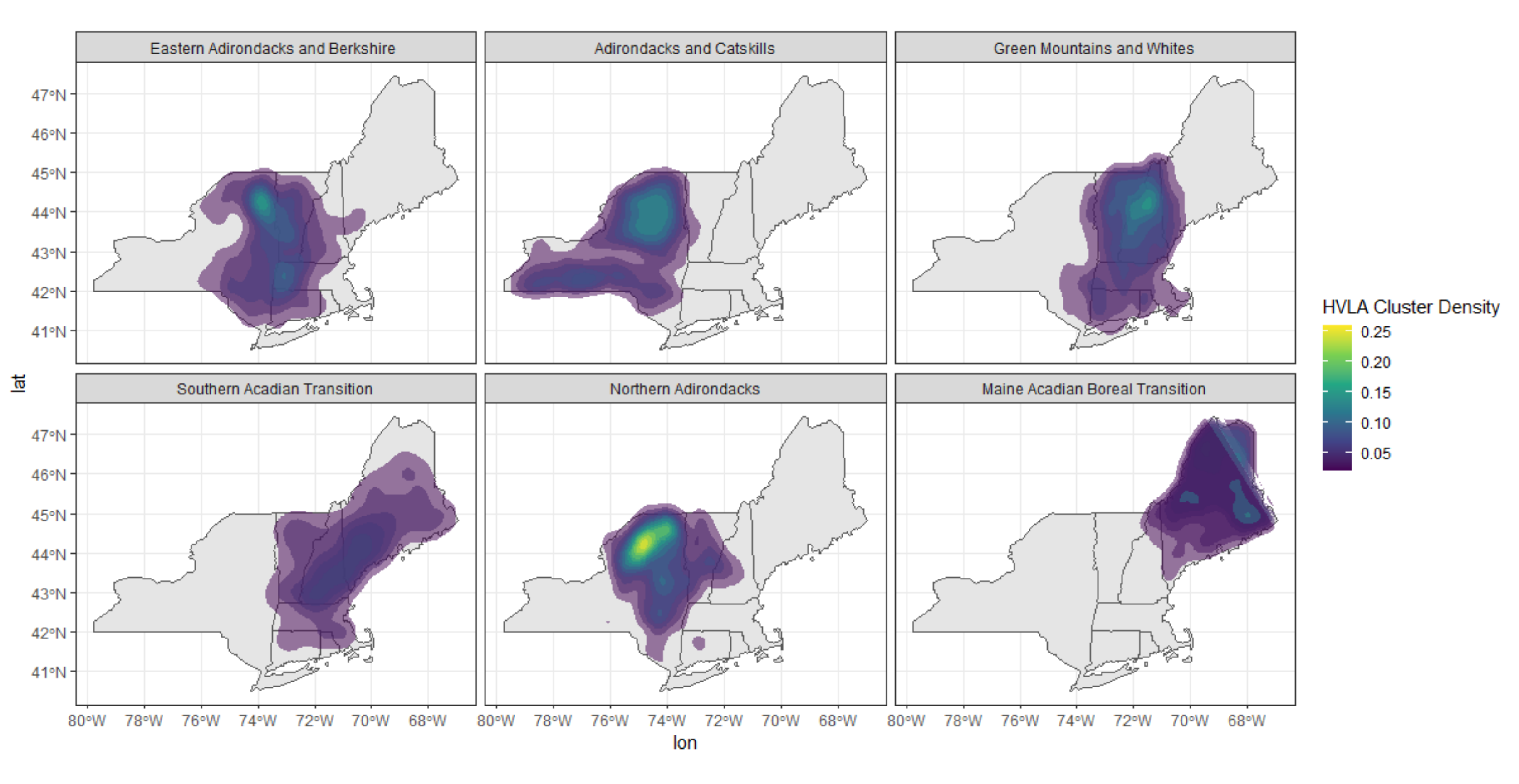
Changes in Vulnerability to Insects and Disease

- Increase in vulnerability to insects and disease
  - Central Acadian transition
- Reduction in changes in vulnerability to insects and disease
  - Northwestern Adirondacks (seedlings)
- Largest average changes in overstory



Clustered Regions of Like Change

- 6 Regions of like change and spatial orientation
- Broad biological patterns close to what we might expect
- Minimal spatial constraining required $\alpha = 0.1$



Broad Characterization of Changes in Score by Cluster

1 ← Worst off (1) to Best off (6) → 6

Region = Southern Acadian Transition

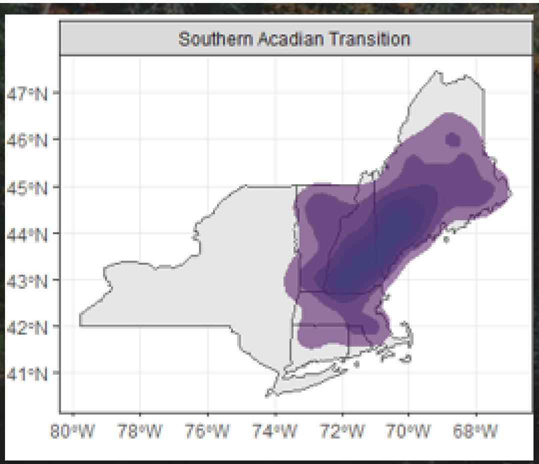
Variable	Mean	SE	Median	SD	Significance	IQR
ADAPT_t_diff	0.16	0.016	0.063	0.406	***	
CCL_t_diff	0.081	0.009	0.052	0.234	***	
CID_t_diff	0.069	0.009	0.052	0.231	**	
ADAPT_s_diff	1.225	0.021	1.152	0.521	***	
CCL_s_diff	0.136	0.016	0.078	0.407	***	
CID_s_diff	0.318	0.031	0.095	0.771	***	

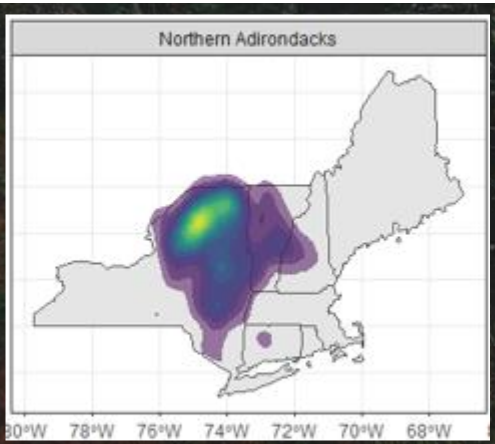
Note: If a p-value is less than 0.05, it is flagged with one star (*). If a p-value is less than 0.01, it is flagged with 2 stars (**). If a p-value is less than 0.001, it is flagged with three stars (***)

Region = Northern Adirondacks

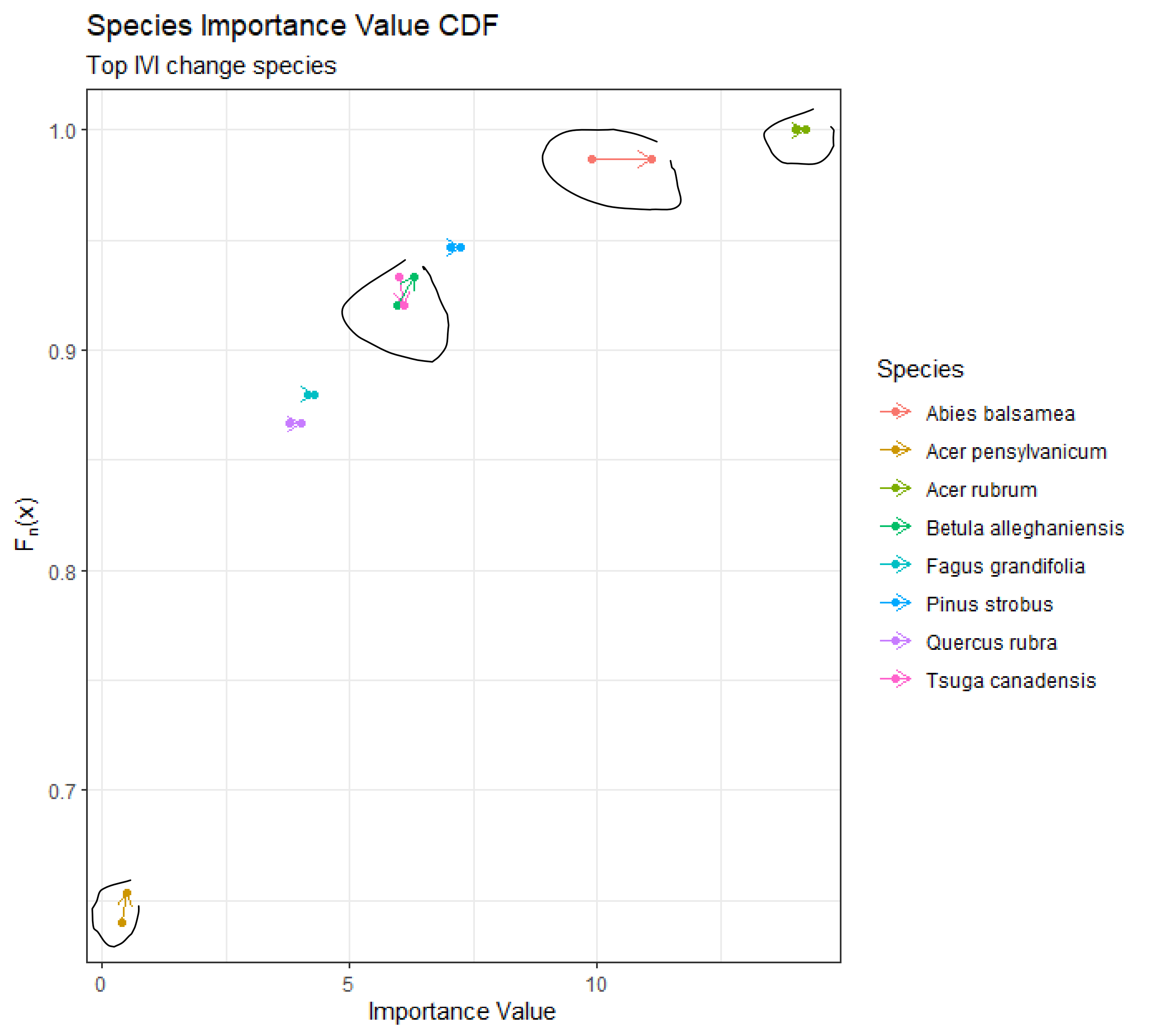
Variable	Mean	SE	Median	SD	Significance	IQR
ADAPT_t_diff	-0.054	0.024	-0.014	0.311	n.s.	
CCL_t_diff	-0.046	0.029	-0.002	0.371	n.s.	
CID_t_diff	-0.014	0.016	0.007	0.199	n.s.	
ADAPT_s_diff	-1.229	0.059	-1.013	0.756	***	
CCL_s_diff	-0.178	0.036	-0.086	0.464	***	
CID_s_diff	-0.156	0.024	-0.064	0.305	***	

Note: If a p-value is less than 0.05, it is flagged with one star (*). If a p-value is less than 0.01, it is flagged with 2 stars (**). If a p-value is less than 0.001, it is flagged with three stars (***)





Species Driving Score Changes in Region



Species in 90th percentile IVI change

- Some dominant species holding and increasing dominance
- Changes in species occurring in center of distribution
- Changes are occurring across whole range

Scientific Name	Common Name	IVI diff	Rank diff
Acer pensylvanicum	Striped maple	0.0965	0.0133
Quercus rubra	Red Oak	0.253	0
Fagus grandifolia	American Beech	0.141	0
Tsuga canadensis	Eastern Hemplock	0.121	-0.0133
Betula alleghaniensis	Yellow Birch	0.346	0.0133
Pinus strobus	White Pine	0.21	0
Abies balsamea	Balsam Fir	1.21	0
Acer rubrum	Red Maple	0.212	0

Conclusion

- There have been changes in overstory and understory adaptability and vulnerability to climate, insects and disease
- The spatial pattern however differ under each scoring system
- Greatest observable changes occurred in regeneration layer
- Considering all variables there are 6 distinct regions of similar changes. Greatest risk regions include:
  - Southern Acadian transition
  - Acadian boreal transition (north and northeastern Maine)
- Species driving this trend appear to be driven by certain species becoming more dominant, as well as less vulnerable species being replaced by other more vulnerable ones

Questions

Works Cited

Woodall, C. W., and A. R. Weiskittel. "Relative Density of United States Forests Has Shifted to Higher Levels over Last Two Decades with Important Implications for Future Dynamics." *Scientific Reports* 11, no. 1 (September 22, 2021): 18848. https://doi.org/10.1038/s41598-021-98244-w.

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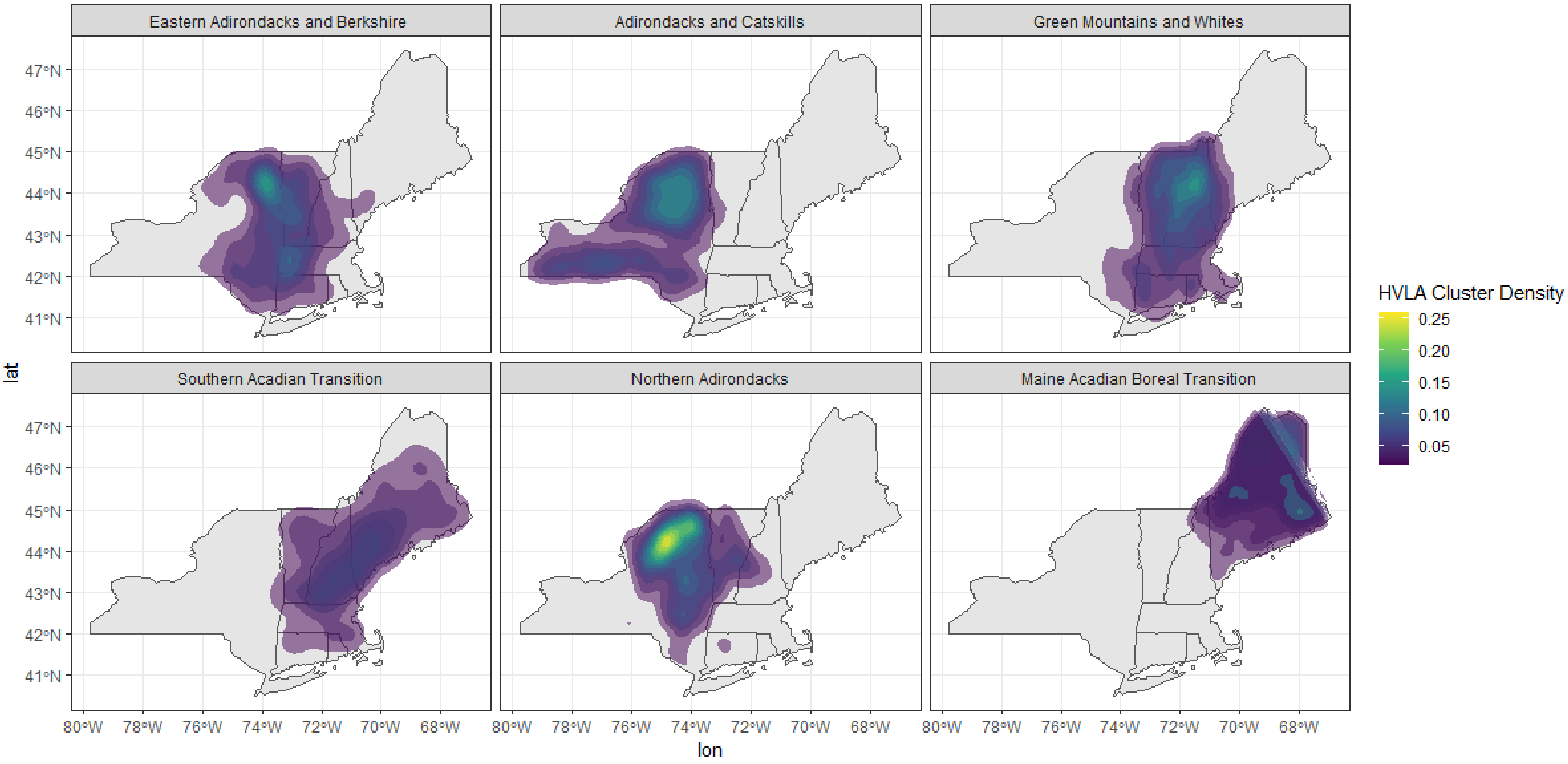
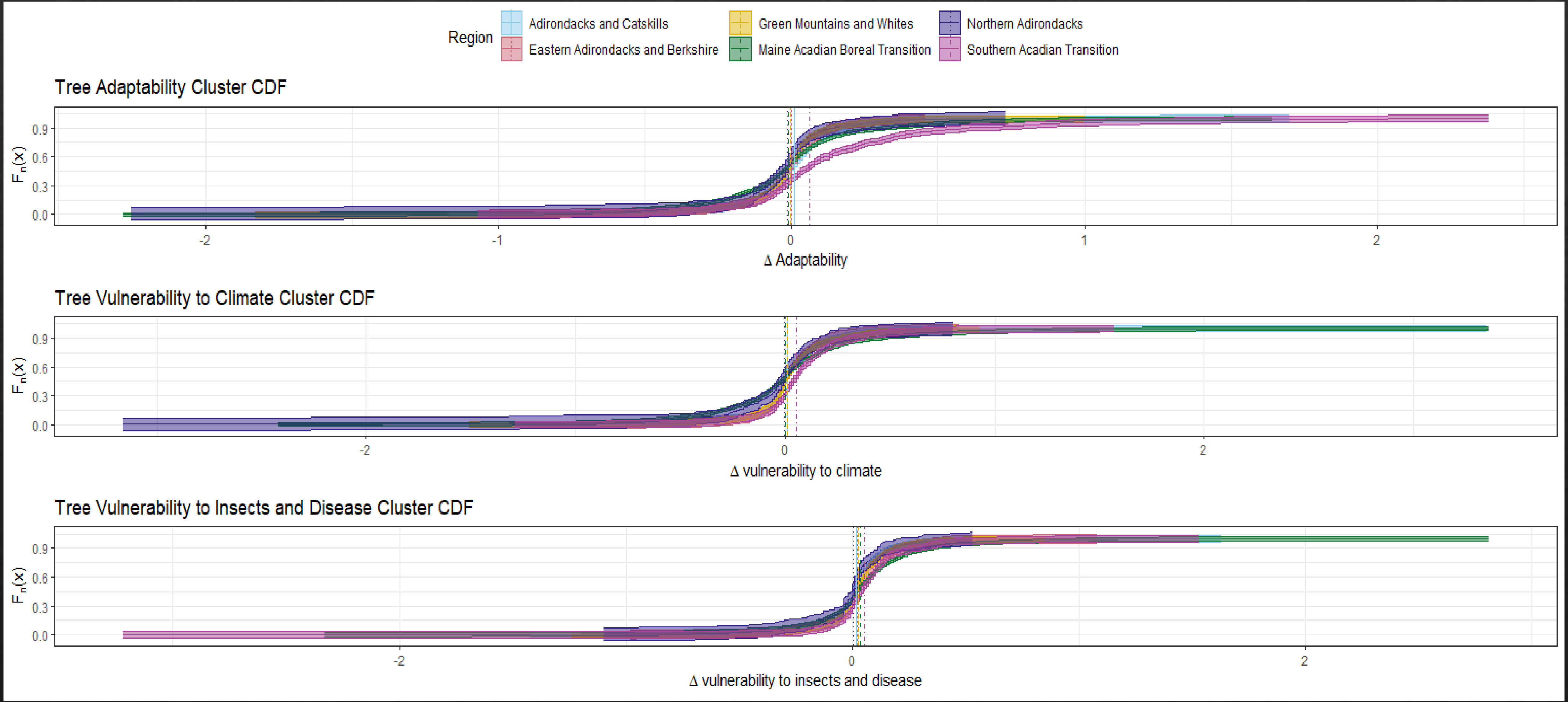
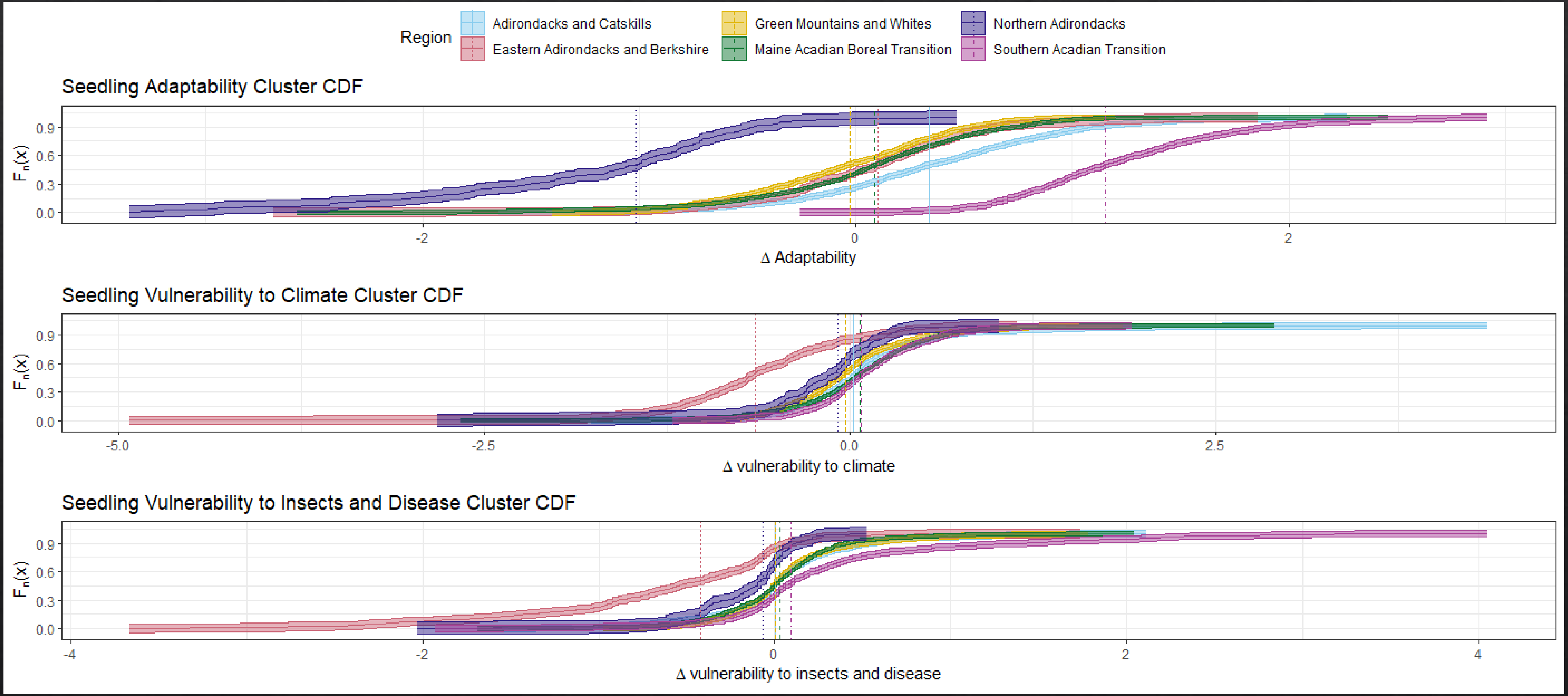
Supporting extra slides


Eastern Adirondacks and Berkshire
Adirondacks and Catskills
Green Mountains and Whites
Southern Acadian Transition
Northern Adirondacks
Maine Acadian Boreal Transition
47°N
46°N
45°N
44°N
43°N
42°N
41°N
lat
80°W
78°W
76°W
74°W
72°W
70°W
68°W
lon
HVLA Cluster Density
0.25
0.20
0.15
0.10
0.05

Tree Clusters



Seedling Clusters



Species Driving Diversity Increases in Region